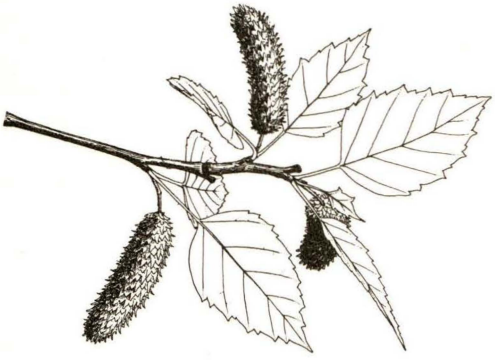
Silvical Characteristics of Paper Birch

(Betula papyrifera)

by Russell J. Hutnik
and Frank E. Cunningham



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Preface

MUCH of the silvical information on our forest trees is widely scattered and sometimes difficult to find. To make this material more readily available, the Forest Service is assembling information on the silvical characteristics of all the important native forest tree species of the United States. It is expected that this information will be published as a comprehensive silvics manual.

This report presents the silvical characteristics of one species. It contains the essential information that will appear in the general manual but has been written with particular reference to the species in the Northeast. Similar reports on other species are being prepared by this Experiment Station, and by several of the other regional forest experiment stations.

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The Paper Birch

PAPER birch *(Betula papyrifera* Marsh) is commonly known also as white birch. The bark, which gives not only name but also unique character to this tree, is distinguishable from the white bark of other species by its pearly surface, its creamy cast, and its chalky whiteness that rubs off onto clothing. This bark separates easily into papery thin layers. Its smooth whiteness is marked with elongated horizontal lenticels *(21)*.

This species is also known as canoe birch and, less commonly, as silver birch *(46)*. The name canoe birch gives credit to the Indians of our eastern woodlands, who laced birch bark onto wooden frames to make canoes that were wondrously strong and light. The bark of the paper birch can be peeled off in strong sheets, and the Indians put it to many other uses too: as covering for their lodges, and to make a variety of utensils.

The wood of paper birch has certain qualities that make it ideal for many turnery and specialty products. It is relatively colorless, odorless, and tasteless; it is light in weight, and straight-grained; it splits easily and works easily.

Spools, bobbins, toothpicks, florist picks, tongue depressors, golf tees, and shoe pegs (now used mainly for polishing), are but a few of the wide variety of turned products and novelty items made from this wood. On the other hand, paper birch wood is not suitable for many ordinary uses: it is too hard for general construction lumber, too soft for hardwood lumber, and is not striking enough in appearance to be popular for furniture or interior finish *(21)*. However, considerable amounts are used for pulp and boxboard.

Figure 1.--The natural range of paper birch, including varieties. A tree of the cold climes, paper birch ranges northward almost to the absolute limit of tree growth.

The turnery and specialty industries sustain a continuing firm demand for this species, and supplies are decreasing. Both industry and forestry agencies are seeking ways to perpetuate plentiful supplies of paper birch through forest management. Sound forest management must necessarily be based on silvical characteristics.

Paper birch has a number of varieties: western paper birch (var. *commutata* (Reg.) Fern.), mountain paper birch (var. *cordifolia* (Reg.) Fern.), Alaska paper birch (var. *humilis* (Reg.) Fern. & Raup), Kenai birch (var. *kenaica* (W. H. Evans) Henry), and northwestern paper birch (var. *subcordata* (Rydb.) Sarg.) *(46)*.

Paper birch, with its varieties, has a transcontinental range (fig. 1). It is common in Alaska and throughout most of Canada, extending northward almost to the limit of tree growth. In the United States it is common in New England, New York, and the Lake States. It also occurs in scattered localities in the other northern states. Outliers are found in Iowa, Nebraska, in the Dakotas, and on a few high mountains of West Virginia and North Carolina *(46)*.

In the United States, paper birch is most abundant in northern New England; and there it reaches its best development. In Canada, one of the regions of greatest concentration is the high land at the headwaters of the Ottawa River in western Quebec *(31)*. The variety Alaska paper birch is one of the common trees in the interior of Alaska *(29, 42)*.

Habitat Conditions

CLIMATIC

Paper birch is definitely a cold-climate species. It is found as far north as the 55°F. July isotherm, with outlying pockets extending almost to the absolute limit of tree growth *(31)*. It seldom occurs naturally where the average July temperature exceeds 70°F. *(61)*.

In view of its transcontinental range, paper birch, as a species, obviously can tolerate much variation in the patterns and amounts of precipitation. In general, the climate of the area where paper birch is found can be described as one of short, cool summers and long, cold winters during which the ground is covered with snow for long periods.

SOILS

Paper birch grows mostly in the region of podzol soils *(60)*. However, it also occurs on gray-brown and brown podzolic soils. Within these great soils groups, it is found on a wide variety of soils. For example, although it reaches its best development on fresh, well-drained sandy

loams such as the Hermon stony sandy loams in New England, it is also common on shallow stony soils *(62)* and even on bog and peat soils.

The soils that support paper birch are mainly glacial tills and outwash derived from granites, schists, gneisses, sandstones, shales, slates, and limestones. They range from acidic to highly calcareous.

Paper birch occurs over a wide range of soil-moisture conditions. It is somewhat more abundant on sites that are a little drier than average *(23, 57)*. Although the typical paper birch is seldom found on very wet or poorly drained soils, the variety *cordifolia* often grows under such conditions in northeastern Minnesota.[1]

Little is known about the nutrient requirements of paper birch. However, studies of a closely related European birch, *B. verrucosa,* have shown that this species requires relatively large amounts of nitrogen and possibly sulfur. It is relatively undemanding of the other elements *(36)*.

Paper birch may even improve soil fertility. There are indications that it increases the exchangeable potassium in the surface of potassium-deficient sandy soils *(65)*. This helps pave the way for succeeding species.

PHYSIOGRAPHIC

In the more favorable parts of its range, paper birch occurs at all elevations, on all slopes and all aspects. It is one of the few hardwoods found near timberline on the highest mountains in New England and New York. In the southern part of its range it is common only on the cooler sites--at higher elevations and on steep north- and east-facing slopes.

In interior Alaska, paper birch predominates on the hill slopes, frequently forming pure stands *(27)*. As a result of fires, it has replaced the climax white spruce stands over wide areas *(48)*. It also occurs on the flat lands in mixture with white spruce and cottonwood *(27)*.

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[1]Zasada, Z. A., Personal correspondence.

BIOTIC

Of the 40 cover types listed in the Boreal and Northern Forest Regions, paper birch is a component of 26 of them *(56)*. It is a major component of five cover types: jack pine-paper birch; aspen-paper birch; paper birch; paper birch-red spruce-balsam fir; and white spruce-balsam fir-paper birch.

Paper birch often grows in pure stands. More frequently though, it grows in mixture with other species. The

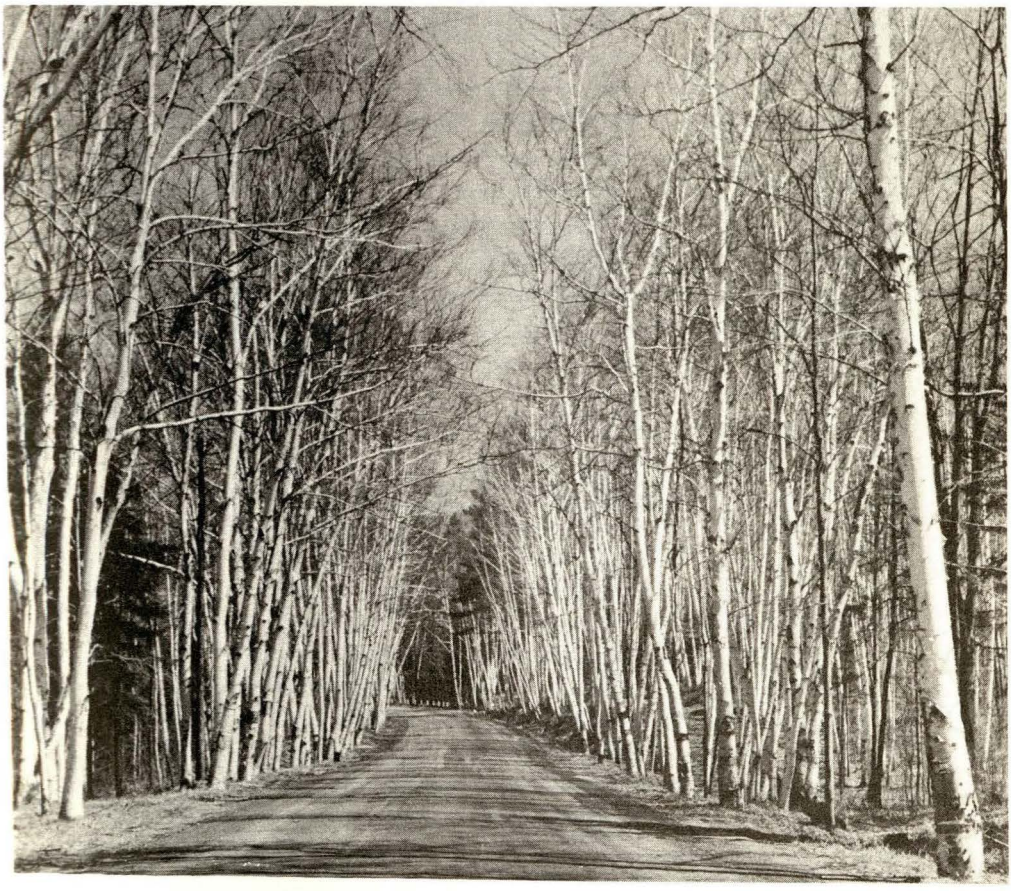

Figure 2.--In the United States, paper birch is most abundant in northern New England. This is one of the famous roadside stands of paper birch at Shelburne, New Hampshire.

best developed trees with the best quality wood are often found in mixture with either white or red spruce and balsam fir *(21)*, or with yellow birch and white ash. Other common associates are quaking aspen, bigtooth aspen, white pine, hemlock, red maple, northern red oak, basswood, jack pine, black spruce, pin cherry, balsam poplar, black ash, red pine, gray birch, and beech.

Forests containing paper birch serve as the home for a great many of our northern animals. Various browse and wood-eating mammals such as moose, deer, snowshoe hares, porcupines, and beaver often rely on paper birch for food. Many birds such as grouse, redpoll, and pine siskin feed on the catkins, buds, and nutlets *(49)*.

Some animals cause considerable damage to paper birch stands. Mice kill many of the young seedlings by girdling them at the ground level *(59)*. Red squirrels have injured or killed many paper birch saplings in Alaska by peeling off the bark *(47)*. Deer are believed to be responsible for the poor survival of many of the paper birch stump sprouts in Maine *(51)*. Browse-clipping studies indicate that if paper birch is to be managed for timber, only light deer browsing can be permitted *(3)*.

Life History

SEEDING HABITS

Paper birch flowers from mid-April till early June *(63)*. The seed ripens in late summer, early August till mid-September. Seed dispersal begins soon after ripening. The seeds are wind-disseminated, and strong winds may carry them considerable distances. However, most of the seeds, despite their light weight, fall rather close to the parent tree.

Paper birch trees begin bearing seed at about 15 years of age *(63)*. The optimum seed-bearing age is 40 to 70 years. Good seed crops, on at least some trees, occur almost every year. Heavy seed crops occur at longer inter-

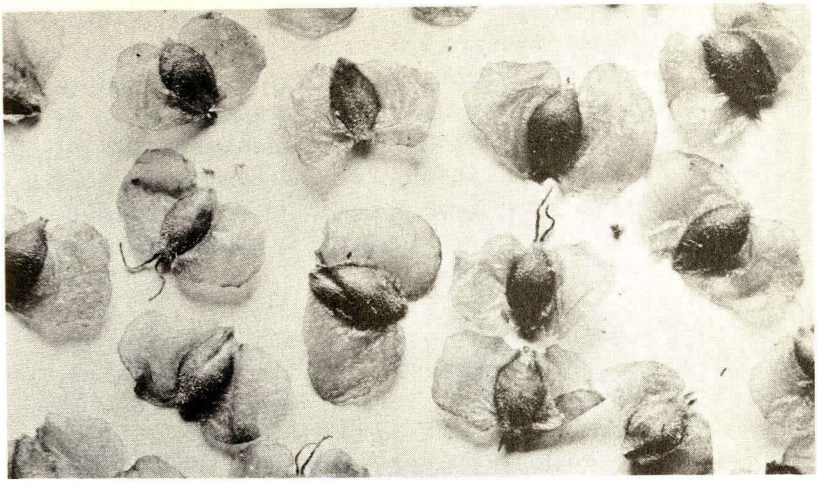

Figure 3.--Paper birch seed (6X). In good seed years mature stands produce huge quantities of seed.

vals. In good seed years mature stands may produce huge quantities of seed. In a current study in Massachusetts, an average fall of 18 million paper birch seeds per acre was recorded in 1955 on 1-chain-wide strips that had been clear-cut through a 70-year-old stand.[2]

The seed, like those of all the birches, is a very small, winged nutlet (fig. 3). It can be distinguished from the nutlets of the other native northeastern birches by certain small but specific differences in size, shape, and pubescence *(20)*. Cleaned paper birch seeds average about 1.5 million per pound. Germinative capacity is rather low, averaging 34 percent *(63)*. Although embryo dormancy sometimes is exhibited, it is not so consistently present and pronounced in paper birch as in many other birch species *(41)*. Paper birch seeds lose their vitality rather quickly when stored unsealed at room temperatures. However, if the moisture content is maintained at about 1 percent, the seeds will remain viable at room temperatures up to 18 months; at moisture contents around 12 percent the storage temperature must not exceed 45°F. *(63)*.

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[2]Cunningham, Frank E. Natural regeneration of paper birch stands. Unpublished progress report, 1957. Northeastern Forest Experiment Station, Williamstown, Mass.

Germination of paper birch seed depends on proper moisture and temperature conditions. It is not affected much by intensity of light, acidity of germinating medium, or carbon-dioxide content of the atmosphere *(41)*. Since a photoperiodic response has been demonstrated in the germination of seeds of the closely related European species, *B. pubescens* and *B. verrucosa (64)*, it is possible that paper birch germination too is influenced by the duration, periodicity, or quality of the light.

After paper birch seed has been stored, both the rate and the percentage of germination can be enhanced considerably by a cold, moist stratification treatment before sowing. Germination percentage can also be increased, but to a lesser extent, by presoaking and by chemical treatment with potassium nitrate, ethylene chlorohydrin, or zinc oxide *(40)*.

VEGETATIVE REPRODUCTION

Paper birch can regenerate from sprouts after cutting or after a fire. Best sprouting usually occurs where young, vigorous trees have been cut in the spring to stump heights of ½ to 1 foot *(51)*. However, regeneration by sprouts after cutting merchantable-sized trees is rather uncertain. In one study in Maine, although 77 percent of the stumps sprouted, only 27 percent of them had live sprouts 3 years later *(51)*, and after 8 years only 16 percent had live sprouts remaining.[3] Sprouting also may occur at the base of standing live trees that have been subjected to increased exposure by removal of nearby trees.

Paper birch may also be propagated by cuttings, provided that the cut surface is treated with a growth-promoting substance *(55)*.

SEEDLING DEVELOPMENT

Because of the small size of paper birch seed, newly germinated seedlings are very fragile. They are sensitive to moisture, light, and seedbed conditions. A mineral soil

[3]Nash, Robley W. Personal correspondence.

is best for germination and initial establishment. Rotten logs are also good seedbeds. On the other hand, leaf litter is especially poor *(35)*. A paper birch seed that germinates on top of a hardwood leaf cannot push its radicle through to the moist soil beneath. If it germinates under a leaf, the tiny seedling is almost always cut off from the light it needs to stay alive. Throughout its life--from the newly germinated seedling to the mature tree--paper birch requires overhead light.

Small paper birch seedlings have shown a pronounced growth reaction to light of very low intensity during the night. This light intensity, considerably less than that required for effective photosynthesis, caused a significant increase in dry matter production *(68)*.

The natural regeneration of paper birch depends almost completely upon natural or man-made disturbances of the forest that provide the requisite conditions of mineral soil seedbeds and overhead light. Paper birch seedlings practically never start and survive in forest areas that have undergone no recent disturbance, whereas reproduction counts have shown high proportions of paper birch seedlings after fires *(7, 8, 48, 50)*, after windthrow *(6, 16, 34, 58)* and after heavy cuttings *(37, 44, 52)*.

Almost all of the paper birch reproduction that comes in after a disturbance becomes established during the first year or two. In a strip-cutting study in a predominantly paper birch stand in Massachusetts, as many as 36,000 seedlings per acre became established during the first year after cutting and soil scarification.[2]

The first year of life is critical for a paper birch seedling. Any appreciable drought period during the growing season will kill many seedlings, especially those whose roots have not reached mineral soil. Competing vegetation may also cut off enough sunlight to kill many seedlings.

Even under favorable conditions, the seedlings that survive average only 3 to 4 inches in height by the end of the first growing season. Only an occasional one exceeds 10 inches. Sprouts, on the other hand, may grow to a height of 2 feet during the first year.

After the first year, growth of the seedlings picks up; at 4 years of age, they may average 3 to 4 feet in height. At this age, sprouts will be about twice as tall.

SEASONAL GROWTH

Seasonal growth begins during the first spring warm spell, even though minimum temperatures may still be below freezing. The first evidence of growth is vegetative bud swelling and flowering, which occur simultaneously. Diameter growth starts after maximum temperatures reach 70°F. or more and minimum temperatures are above freezing. Temporary abrupt increases and decreases in diameter growth in the spring and fall are correlated with sudden rises and falls of temperature but not with rainfall *(2)*. As in most species, diameter growth ceases well before either moisture or temperature become limiting *(24)*. In general, paper birch begins and ceases diameter growth later than most of its associates *(11)*.

Seasonal height growth, which also begins before the threat of frost is over, starts slowly in paper birch, rises gradually to a peak of maximum growth in mid-June, and then drops off gradually. Compared to other species, paper birch has a long period of height growth *(43, 45)*. Seedling height growth may be prolonged indefinitely under long-day conditions, whereas short days cause the cessation of terminal growth *(25)*.

SAPLING STAGE TO MATURITY

Growth during early life is rapid. Individual trees often attain a diameter of 8 inches in 30 years *(12)*. The growth rate then begins to fall off, and in old age it becomes almost negligible *(21)*.

Mortality is heavy throughout the life of a paper birch stand. Individual trees express dominance early in life. Unless suppressed trees are released early, they soon die. Intermediate trees survive longer, but gradually succumb after struggling along for years at a low growth rate.

Despite the high mortality, paper birch stands are usually dense. Not until the trees become overmature does

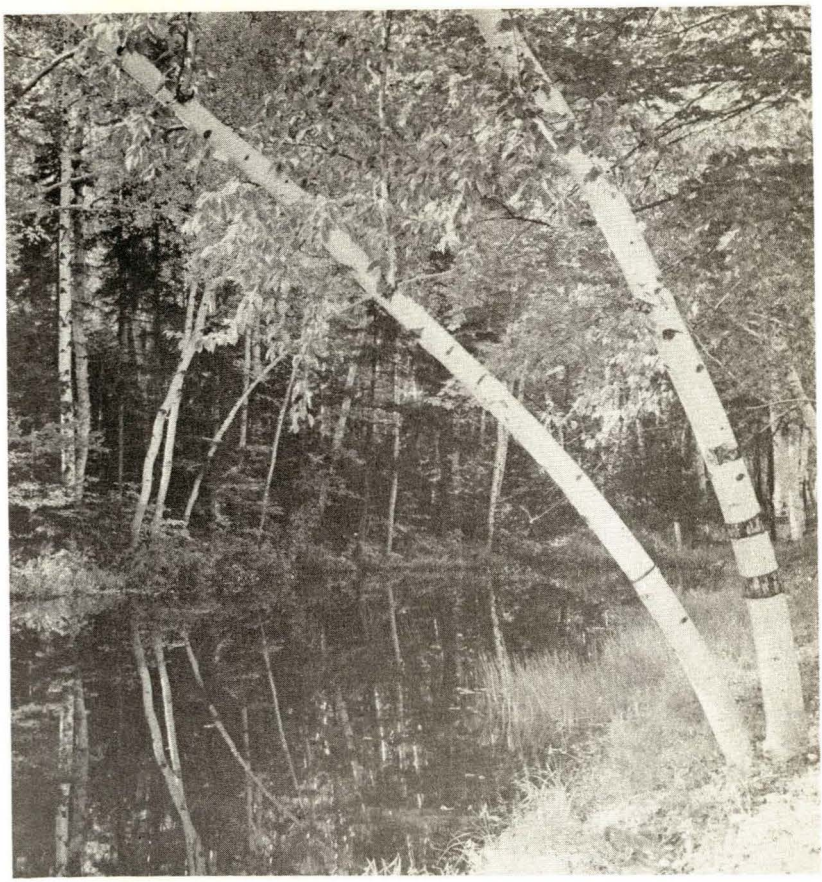

Figure 4.--The whiteness of paper birches brings beauty to many a woodland scene. Once the papery white outer bark is peeled off, it never grows back. Instead, a black scar is left.

the continued mortality, combined with crown decadence and reduced growth, result in a decrease in stand density. In pure stands, reproduction of more tolerant species such as spruce and fir then becomes firmly established. In mixed stands, the associated species become increasingly more prominent at the expense of the paper birch.

Paper birch is considered a short-lived species. Trees mature in about 60 to 75 years. Few live longer than 140 years. But an occasional tree may reach an age of 200 years.

Figure 5.--A fine mature 16-inch paper birch in the Berkshires of Massachusetts. On the best sites paper birch may grow to 30 inches in diameter and 100 feet in height.

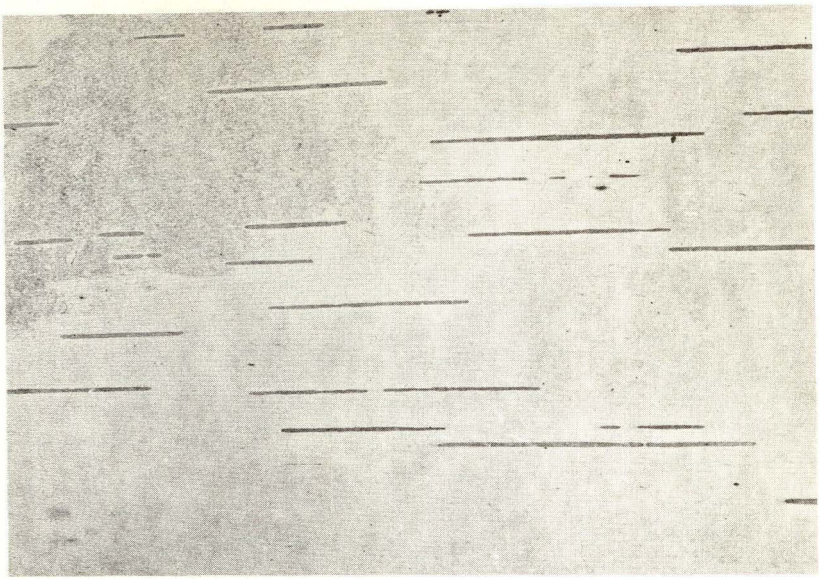

Figure 6.--The bark of paper birch. The creamy whiteness is marked with horizontal lenticels.

Mature paper birch trees grown under forest conditions are taller and better formed than most of their associates. They have long, clear lengths up to the first branches, with relatively little taper. Epicormic branching is common on weakened trees and on trees that have been exposed through logging.

The root systems of paper birch are shallow but widespreading, and provide considerable resistance to windthrow *(1)*. However, in stands opened up by thinning, uprooting may occur, particularly among the taller, larger-crowned trees *(38)*.

Trees in mature stands average about 10 inches in diameter and 70 feet in height. Usually, though, there are many fine trees in the 12- to 18-inch diameter classes (fig. 5). On the best sites an occasional tree in old stands may exceed 30 inches in diameter and 100 feet in height. The variety *cordifolia* grows as large as 40 inches in diameter.[4]

[4]Zasada, Z. A. Personal correspondence.

Figure 7.--The dying tops are a sign of decadence in paper birch. This condition often develops where cuttings expose the paper birch.

Yields of pure paper birch stands vary with age and site quality. Good sites in New England will produce around 3,000 cubic feet or 31 cords in 50 years. On poor sites the yield may be somewhat less than 2,000 cubic feet or 20 cords *(21)*. In Alaska, yields as high as 30 cords per acre have been reported *(22)*.

Paper birch is rated as an intolerant tree *(4)*. Among its common associates in the Northeast only aspen, pin cherry, and gray birch are more intolerant *(26)*. In the natural succession, paper birch usually lasts only one generation, being replaced by more tolerant species. In the northern Lake States, however, it is a common component of the climax white spruce-balsam fir-paper birch type *(14, 18, 56)*. And even in some other areas, it occurs as a widely scattered tree in climax forests. Therefore, a paper birch seed source is usually present.

Paper birch responds relatively little to thinning. Growth rates will increase, but not nearly so much as for most other species. This low response is due in part to the fact that the released trees usually are those that had already been in a dominant position.

Thinnings or other cuttings should always be made with care, because a condition known as post-logging decadence often develops where paper birches have been exposed by opening the stands (fig. 7). The symptoms include lowered vigor, reduced growth, dying back of twigs and branches, and, in many instances, eventual death of the tree. To prevent this decadence, thinnings should always be light, removing no more than a third of the basal area of the stand. Even after such light thinnings some decadence may set in, but recovery is possible *(38)*.

A closely related condition termed birch dieback has almost identical symptoms *(32)*. The two are differentiated in that birch dieback may occur in undisturbed stands, whereas post-logging decadence is induced by opening the stands. During the 1930's and 1940's, there was widespread dying of both paper birch and yellow birch in eastern Canada and in Maine as a result of birch dieback. By 1951, an estimated 67 percent of the birch in Maine had been killed *(51)*. At present little merchantable birch remains in the forests of the Canadian Maritime Provinces *(54)*.

Despite considerable investigation, no one factor has been definitely shown to be the cause of birch dieback. It is known that rootlet mortality usually precedes the crown symptoms *(28)*. It has been demonstrated that artificial heating of the soil during the growing season will cause rootlet mortality and symptoms similar to those of birch dieback *(53, 54)*; hence, it has been postulated that climatic changes leading to increased soil temperatures could be the cause of this malady *(33)*. Although no fungus or virus has ever been positively associated with birch dieback *(30)*, it remains a possibility that some such organism is the causal agent *(54)*. Recent evidence strongly suggests that dieback in yellow birch, and presumably in paper birch, is caused by a virus infection rather than by climatic changes *(17)*.

Usually associated with both dieback and decadence is an insect, the bronze birch borer *(Agrilis anxius)* *(5)*, which often kills weakened trees. During the outbreak in Maine in the 1940's it was considered very aggressive *(51)*. Yet most experts do not consider it the cause of dieback, although it may be a determining factor in the death or recovery of trees *(9)*.

Figure 8.--Red heart is a serious defect in paper birch. A discoloration that resembles heartwood, it is believed to be caused by parasitic organisms.

At times the forest tent caterpillar *(Malacasoma disstria)* is a serious enemy of paper birch. Repeated attacks are especially injurious. Annual growth may fall below normal by as much as 86 percent during the third year of complete defoliation *(10)*. Several other leaf-eating insects feed on paper birch, but ordinarily do little damage *(19, 66)*.

Except for Alaska birch, which is very susceptible to decay *(22)*, vigorous stands of paper birch contain little defect. The most important rot-causing fungi attacking the species are *Fomes igniarius* and *Poria obliqua (13)*.

A defect that limits the use of paper birch for many specialty products is red heart (fig. 8), a reddish-brown discoloration of the central part of stems and branches. Although this condition resembles natural heartwood, there is an abnormal difference in that red-heart wood is wetter than the surrounding sapwood. Also, red heart is much more extensive than natural heartwood; sometimes it extends through almost the entire cross-section of the bole. The condition is believed to be caused by parisitic organisms *(15)*. Since paper birch is used in the manufacture of turned articles, for which white wood is preferred, the presence of red heart is objectionable.

Fire, which is responsible for the establishment of many paper birch stands, is also one of the most serious enemies of established stands. Because the bark of paper birch is thin and highly inflammable, even large trees may be killed by moderate fires.

Races and Hybrids

No races of paper birch have been recognized, although it is quite possible that such races exist.

Polyploidy is very pronounced in paper birch and its varieties. *B. papyrifera* has 35 pairs of chromosomes while its varieties have 28 to 42 *(67)*.

Hybridization in birches is rather common. Among the natural hybrids are Sandberg birch *(Betula x sandbergii* Britton), Yukon birch *(Betula* x *eastwoodiae* Sarg.), Horne birch *(Betula* x *hornei* Butler) *(46)*, and unnamed hybrids of paper birch with yellow and gray birch. [5]

Paper birch has also been crossed experimentally with a number of other birches *(39, 55, 67)*. One interesting hybrid between gray birch and paper birch grows faster than the paper birch parent, though slower than gray birch; outwardly it resembles a good type of paper birch *(55)*.

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